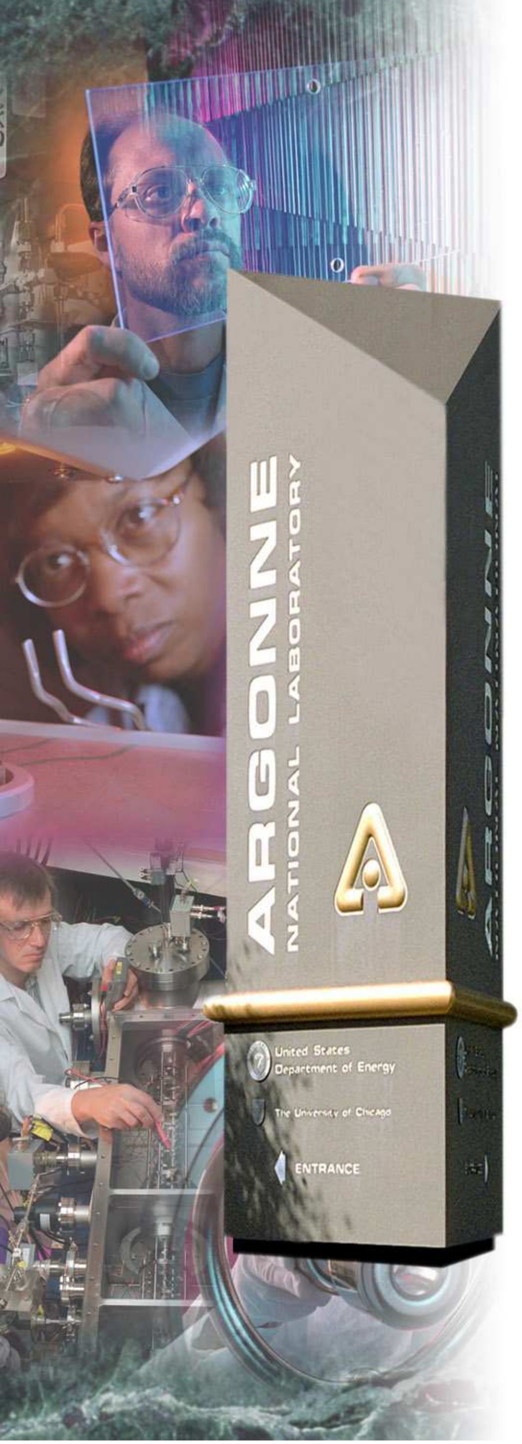

Simulations and Simulation Codes

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Why Write Simulation Codes?

- **Design and improvement of accelerators requires increasingly sophisticated simulation codes**
- **Commercial codes and many free codes are closed source**
  - Have to trust that the right physics is used
  - We can't add new physics or algorithms
  - Must wait for bug fixes
  - Must accept the interface someone else provides
- **We develop our own codes**
- **We modify existing open-source codes to fit our methods**

Advantages of SDDS-Compliant Simulations

- **All OAG-created and OAG-modified simulations are SDDS-compliant**
- **SDDS files provide a communication standard**
  - Between multiple codes
  - Between codes and the control system
- **The payoff for APS is**
  - Effective utilization of cluster-based computing facilities
  - Faster upgrades to codes to meet new needs
  - Faster development and evaluation of accelerator improvement ideas
  - Ability to do very complex, thorough simulations
    - *Top-up safety tracking (about 3000 runs)*
    - *Evaluation of short bunch production in the booster*

Some APS Applications of Elegant

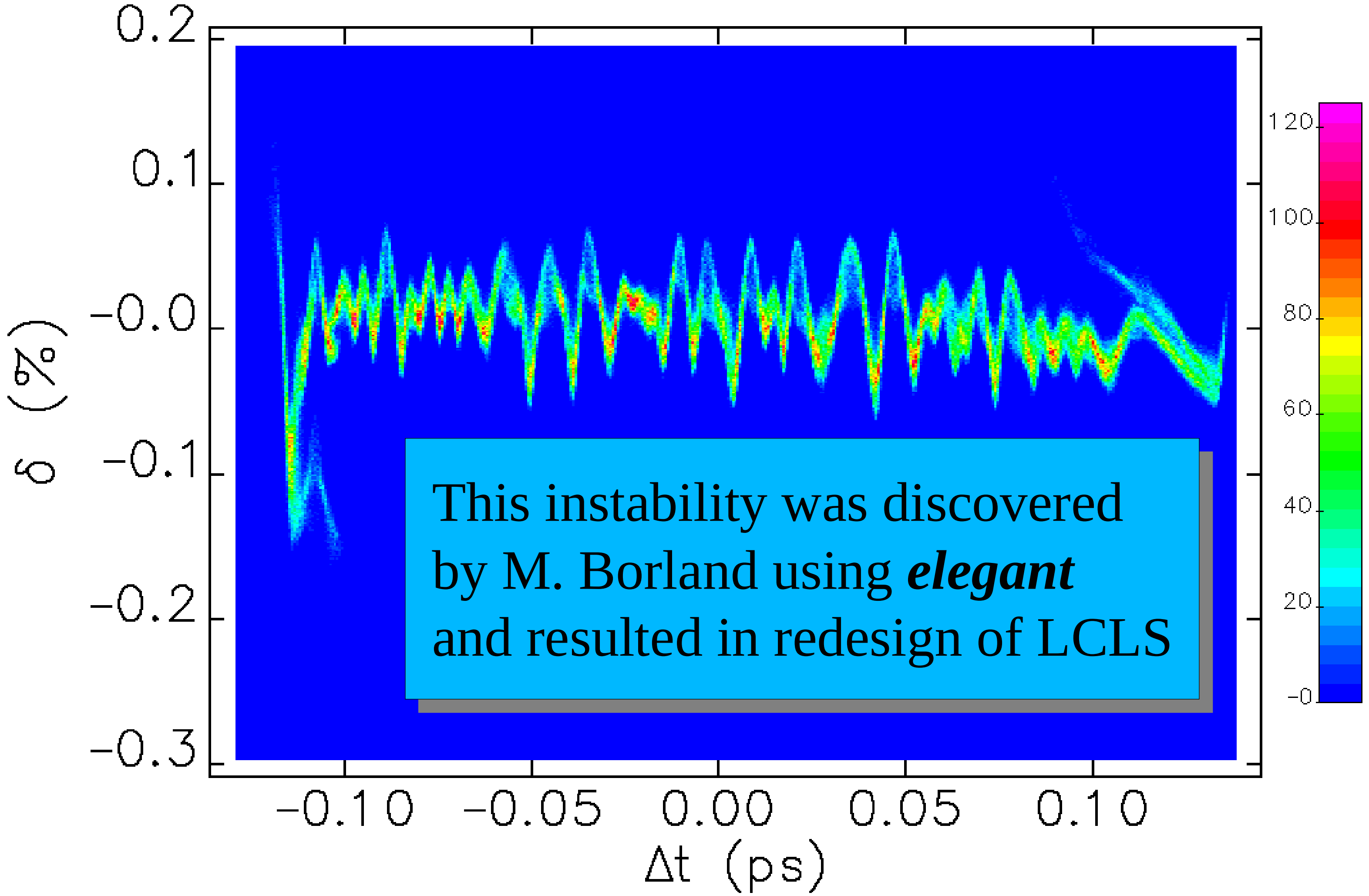
- **elegant (Borland) is a code for accelerator design**
- **Current APS accelerator lattices (OAG)**
  - SR low-emittance and Decker-distorted lattices
  - Booster low-emittance
  - PAR
  - New linac configuration with bunch compressor
  - All electron beam transport lines
- **Optics calibration software (Sajaev)**
- **Optics correction software (Emery)**
- **Lower-emittance lattice exploration (Borland)**
- **Long-straight section lattice development (Borland, Sajaev)**
- **Create matrices for orbit correction and steering (Emery)**
- **Simulation of beam disruption by top-up (Borland)** *Movie*

Some Non-APS Applications of Elegant

- **About 200 users have downloaded elegant and other codes from our web site**
- **Users come from all the major accelerator labs: BNL, DESY, Fermi, INFN, KEK, SLAC, SPRING8, SSRL, Trieste, ...**
- **There have been many applications by these users and by OAG staff**

CSR Microbunching Instability

06Dec00 Design



This instability was discovered by M. Borland using ***elegant*** and resulted in redesign of LCLS

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SLAC's SPPS Project Used elegant (Fermi News 12/1/03)

SPPS project at SLAC creates first linac-produced x-rays

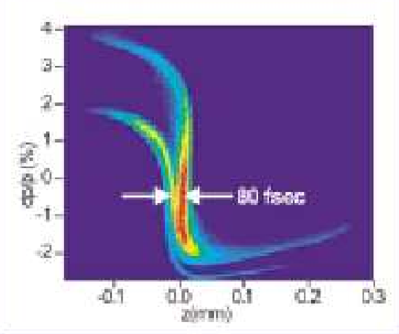
These first-ever linac-produced x-rays, at Stanford Linear Accelerator Center, are 1,000 times shorter than those previously made by storage rings at SLAC, at Argonne National Laboratory and at other labs, to illuminate microscopic materials.

"These ultra-short, very bright x-rays enable experimenters to make direct observations of atomic motion in matter that have never been seen before," said Jerry Hastings, assistant director of the Stanford Synchrotron Radiation Laboratory at SLAC, which Stanford manages for the U.S. Department of Energy. Scientists in the fields of chemistry, biology and materials science, from industry, universities and other labs, can use these x-rays to take instant pictures of simple chemical reactions in progress in solids and liquids.

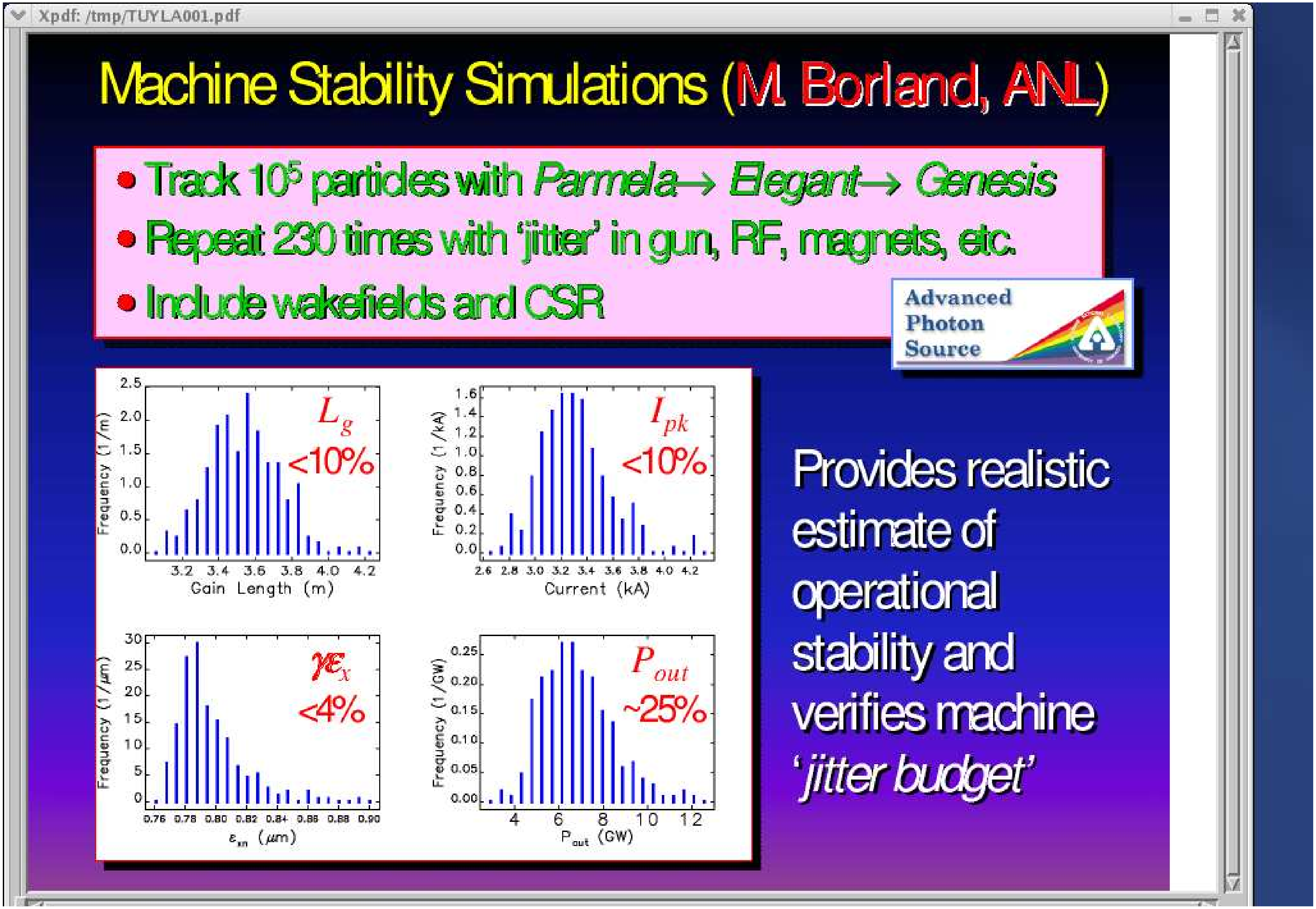
The project, called the Sub-Picosecond Pulse Source (SPPS), is an important stepping stone on the way to making even shorter and brighter x-rays later this decade with the world's first free electron laser (called the Linac Coherent Light Source or LCLS), which will also use the SLAC linac. The SPPS, first tested last spring, is now producing x-rays for experiments.

SPPS compresses each bunch of about 21 billion electrons from 6 millimeters down to 12 microns (millionths of a meter). Traveling at the speed of light, the bunch whizzes past a fixed point in 80 femtoseconds (quadrillionths of a second). Packing more electrons together produces more current, producing brighter x-rays. The compressed bunches reach a peak current of 30 kiloAmperes—about 1,000 times greater than the current that flows through a household fuse.

Manipulating the shape and size of electron bunches has become a science in itself. To compress the bunches, SPPS researchers rely on several tricks that can only be done at SLAC where the electrons pick up speed and energy— 28 billion electron volts—on their two-mile journey down the linac.

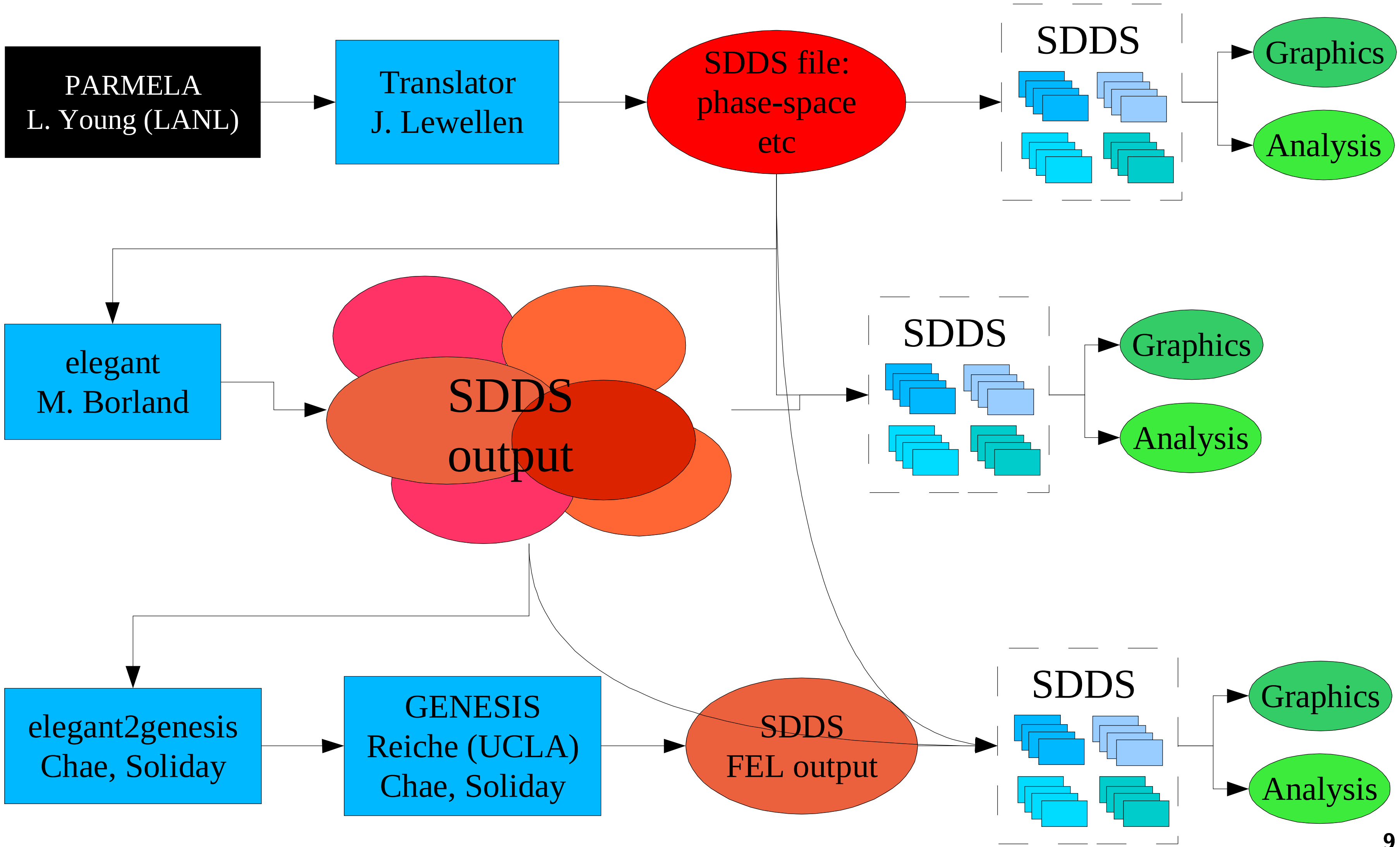


The simulated longitudinal phase space of the electron bunch after all three stages of compression. The horizontal axis in this image represents distance and shows an 80-femtosecond long bunch, while the vertical is relative energy (or momentum) deviation. The simulation was made using a computer code written by Michael Borland at ANL.



P. Emma, EPAC 2003

SDDS Makes One Code From Many: LCLS Start-to-End Simulations



Some APS Applications of shower

- **Shower (Emery) calculates electron-gamma showers due to beams hitting matter**
- **During construction, used for verification of APS shielding designs (Emery)**
- **Simulations related to ID damage**
  - Radiation dose to APS undulators (Emery)
  - Radiation dose to LEUTL undulators (Emery)
  - APS scrapers redesign (Borland, Emery)
  - Beam collimation in the BTS (Borland)

Some APS Applications of spiffe

- spiffe (Borland) is a code for rf gun design and simulation
- Was used to design the thermionic rf guns used by APS

Movie

- Used, with elegant, to determine the cause of poor performance of RG1

Conclusion

- **OAG's simulations and codes continue to make**
  - Key contributions to accelerator improvements at APS
  - Substantial contribution to the wider accelerator community
  - Substantial contribution to the reputation of APS
- **This results from a powerful combination of**
  - Up-to-date physics
  - Working with real machines
  - Innovative, practical computer science concepts